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SAAC (LASA) EQUIPMENT AND SOFTWARE PERFORMANCE

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SEISMIC ARRAY ANALYSIS CENTER

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The performance of both processors was high. The Detection Processor operated 97% of all available time throughout the second half of the year. The Event Processor report coverage was virtually the same as DP recording coverage throughout most of the year.

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SAAC (LASA) EQUIPMENT AND SOFTWARE PERFORMANCE

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LIST OF ACRONYMS

ALPA	Alaskan Long-Period Array
CPU	Central Processing Unit
DP	Detection Processor
DOS	Disk Operating System
EOC	Experimental Operations Console
EP	Event Processor
GMT	Greenwich Mean Time
IISPS	Interim Integrated Signal Processing System
ISRSPS	Integrated Seismic Research Signal Processing System
LASA	Large Aperture Seismic Array
NORSAR	Norwegian Seismic Array
SAAC	Sesimic Array Analysis Center
SAQ	Signal Arrival Queue
SPS	Special Processing System
TROS	Transformer Read Only Storage

INTRODUCTION

This report is a presentation of the equipment and software performance of the Seismic Array Analysis Center (SAAC) automatic seismic data acquisition and processing system. An evaluation of the system must include a measurement of the performance of its equipment and software since this has a direct bearing on the system effectiveness. The Geophysical Evaluation of this system is found in SAAC Report No. 5 (Dean, 1972).

The SAAC System is on-line to the LASA Data Center via telecommunications link. It uses the LASA short-period seismic data to automatically detect and locate seismic events. The on-line SAAC system also records and beams LASA, ALPA, and NORSAR long-period seismic data in real-time and transmits ALPA data to other users. These tasks are secondary to the main mission of the on-line SAAC system.

The equipment and software systems examined here are those which perform the on-line seismic data analysis. They consist of two IBM S/360 Model 40 computing systems and the Special Processing System 4103, using the Integrated Seismic Research Signal Processing System (ISRSPS) real-time Detection Processor and an off-line Event Processor programming system.

The interval covered in this report is from January 15 through December 31, 1971. In the System Configuration Section we describe the equipment to be examined.

This report reviews SAAC equipment and software performance by examining three areas:

1. measurements of uptime for the total system and for each component of the system;
2. description and use of backup equipment;
3. description of the flexibility of the system.

The first area, measurement of uptime or recording time, is important as a direct measure of the reliability of the equipment and software. It serves as a reference point for measuring the effect of parameter changes on the number of seismic events reported. This is discussed in the Performance Section.

The second area, the description of the capability and utilization of alternate hardware, shows to what extent the recording time was improved by this backup capability. This discussion is in the Alternate Equipment Section.

In the third area of this report (System Flexibility) we discuss the flexibility of the system.

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SYSTEM CONFIGURATION

The SAAC automatic processing system is composed of two subsystems, each located in a separate computer as shown in Figure 1. One is the on-line real-time Detection Processor; the other is the Event Processor. Both systems operate under the control of a Disk Operation System (DOS).

The Detection Processor (DP) receives LASA, NORSAR, and ALPA data via telecommunication links, reformats these data, forms beams, records the data on magnetic tape, prints error statistics, detect and records short-period signals, and displays instrument status and seismic data. This part of SAAC consists of two computers: one a special microprogrammed computer for data acquisition, subarray beamforming, and filtering; the other an IBM S/360 Model 40 general-purpose computer system for recording, signal detection, and display. The IBM S/360 computer has 262,000 bytes of main memory, and its central processing unit has six additional special instructions for filtering and beamforming which ensure the necessary computing speed.

Figure 2 is a diagram of the SAAC computing system. It presents all the peripheral devices associated with the DP system. The Experimental Operations Console (EOC) is a custom display console which displays beam

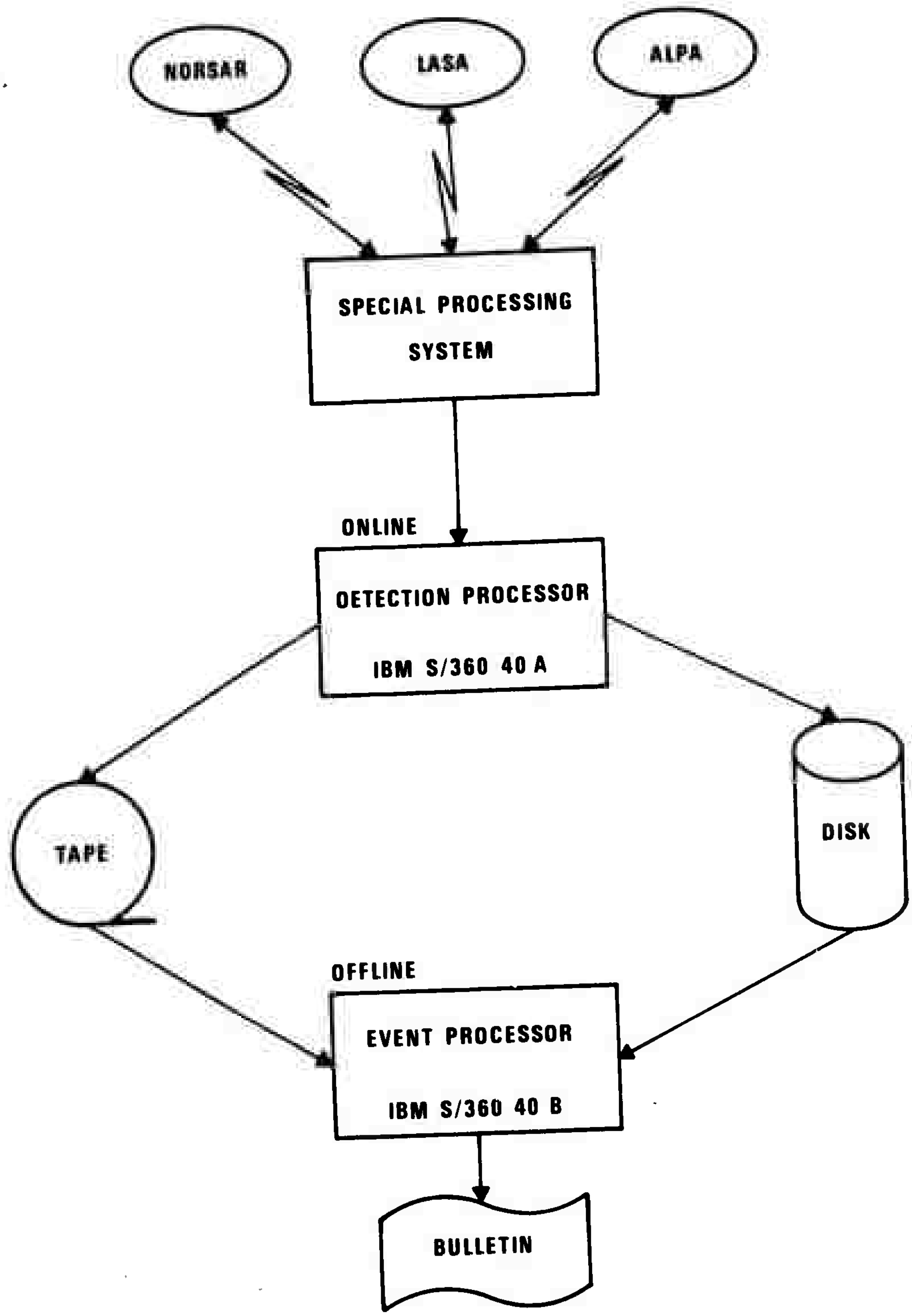


Figure 1. Overview of the SAAC system.

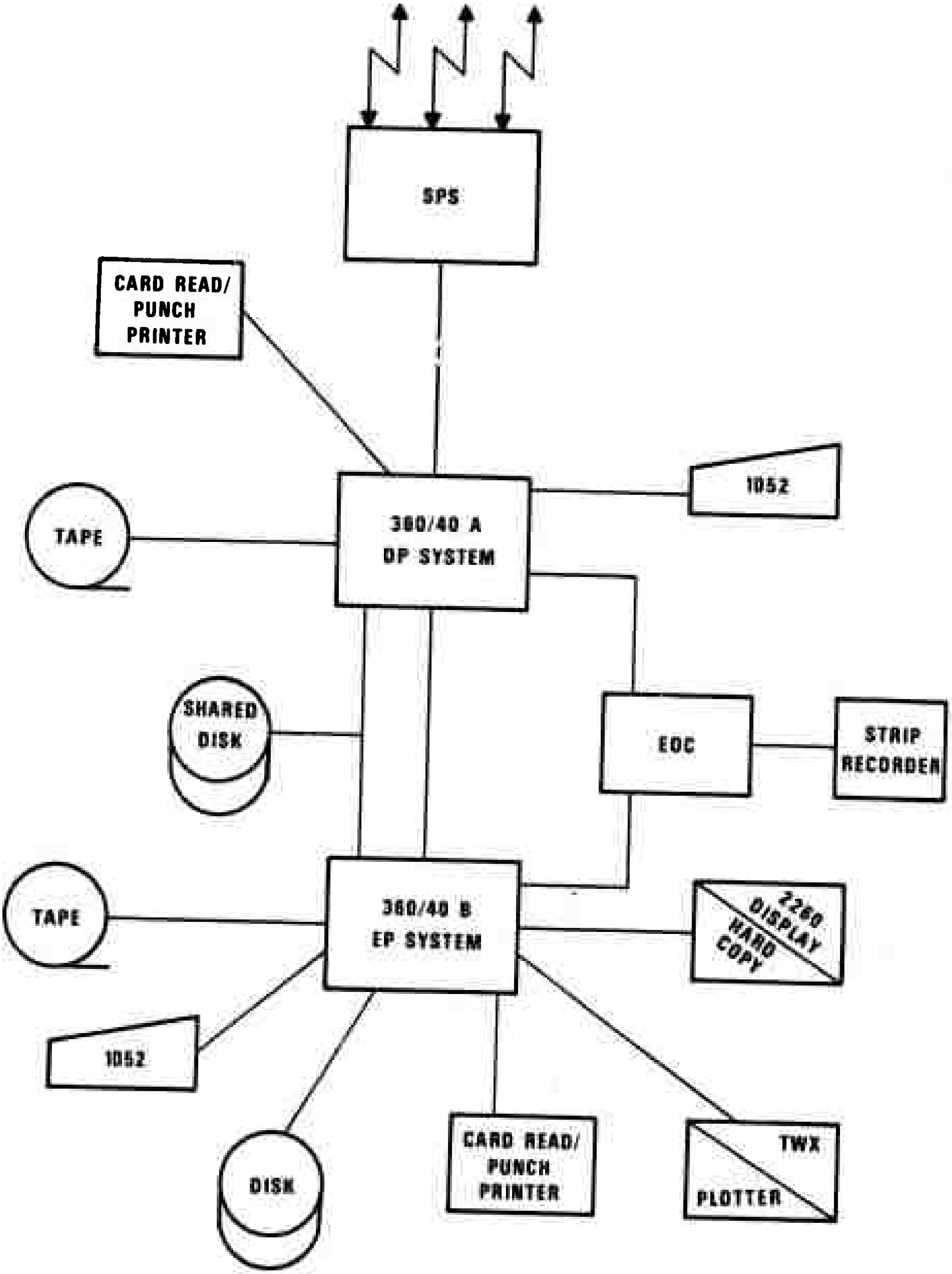


Figure 2. SAAC computer configuration.

activity, seismic data and instrument status. It has a strip chart unit for producing a permanent copy of the data display traces. The Special Processing System (SPS) is a custom microprogrammed computer. All other equipment is standard.

The Event Processor (EP) selects signals or groups of signals for event analysis from the file of detections recorded by DP on the shared disk. Using the data tapes recorded by DP, the EP system refines the estimates of event location and characterizes events. EP produces an event bulletin, which is a summary report of the parameters of each event, and plots of beam waveforms. EP also produces an Event Tape which contains waveforms and the event bulletin, and provides a seismic analyst with the options of editing the results of the automatic processing and invoking re-analysis of events.

The EP system at SAAC consists of an IBM S/360 Model 40 computing system identical to that used in the DP system. Figure 2 shows all peripheral devices of the EP system and points of interface to the DP system. Analyst review and edit functions are performed through the Experimental Operations Console. The channel-to-channel adapter permitting direct communication between the S/360 computers is used by DP to notify the EP system of a large event. The 1627 plotter is used in

an off-line mode to plot beam traces from the EP plot tape. The teletype terminal (off-line to EP) is used to transmit the LASA Daily Event Summary to other seismic research laboratories.

HARDWARE/SOFTWARE PERFORMANCE

Detection Processor

Recording on the DP system began at 2300 GMT January 15, 1971, following the move of the SAAC and checkout of the equipment.

To trigger a signal detection, the beam with the highest energy must be in the same neighborhood for p out of p' successive 0.6 second time intervals, and the signal-to noise ratio must exceed a fixed threshold at least 3 out of 3 times. Throughout the year the fixed threshold was set to 10 db. From January 15 through February 17, 1971 p and p' were set to 3. From February 18 through December 31, 1971 p and p' were set to 4. Further information on system operational parameters may be found in SAAC Report No. 5 (Dean, 1972).

Figure 3 is a histogram of the daily recording time (beginning on February 1, 1971) of the DP system given in percentage of the 24 hour day. The long downtime on May 17 and 18 was due to a change in the routing of the 50 kilobit line by the telephone company.

Table I summarizes recording downtime hours by cause. The low recording times in January and early February reflect the only downtime for training, which includes training classes, familiarization difficulties, and deficiences in operational and software manuals.

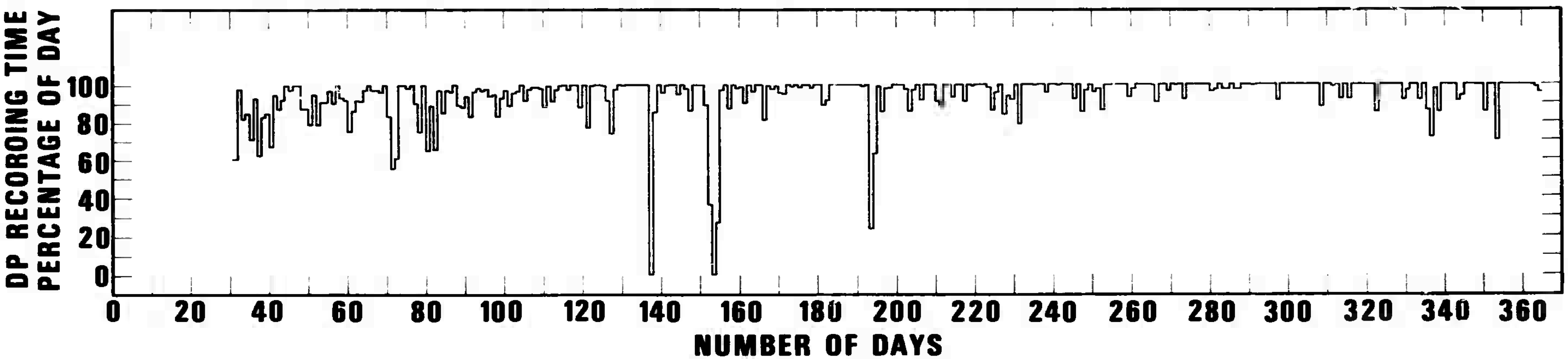


Figure 3. DP daily recording time (percentage).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
50 Kilobit Line	56.8	12.7	14.0	3.7	50.2	17.3	30.6	12.0	5.6	3.2	4.3	21.0	231.4
SAAC Computer Room	-	31.4	13.7	11.8	1.2	9.2	4.9	6.5	4.7	.8	1.6	.6	86.4
Prev. Maint.	5.4	6.6	8.0	9.0	6.3	5.0	10.2	5.2	8.5	2.9	8.4	6.4	81.9
Software*	-	-	-	-	-	-	-	-	.5	1.7	.2	.5	2.9
SPS	12.4	3.5	41.3	16.9	0.0	42.1	.0	.0	.7	.0	.1	.0	117.0
Training	96.0	-	-	-	-	-	-	-	-	-	-	-	96.0
Total DP Down-time	170.6	54.2	77.0	41.4	57.7	73.6	45.7	23.7	20.0	8.6	14.6	28.5	615.6
Total DP Uptime	214.4	617.8	667.0	678.6	686.3	646.4	698.3	720.3	700.0	735.4	705.4	715.5	7785.4
Total Possible Recording time	385.0	672.0	744.0	720.0	744.0	720.0	744.0	744.0	720.0	744.0	720.0	744.0	8401.0
% Uptime	56%	92%	90%	94%	92%	90%	94%	97%	97%	99%	98%	96%	91.3%

* Outage due to software is included in the SAAC computer room figure from Jan through June.

Table I. Summary of ƆP Up/Downtime in Hours

The 50 kilobit line category accounted for 38% of all DP recording time lost; the SAAC computer room, which includes the S/360 Model 40 and its peripheral devices, for 14%; scheduled preventive maintenance for 13%; software for 0.15%; SPS for 19%; and training for 14%.

The 50 kilobit line from LASA to SAAC is the least reliable part of the system. Generally the LASA line failures were associated with bad weather along the route of the line, particularly in the mid-western region.

The SPS had difficulties during the first part of the year, but during the period from July 1 through December 31 it had virtually no failures. It would appear that failures were caused by the move of equipment. The SPS microprogramming had no errors.

The average daily DP recording time for all 1971 was 91.3% of the 24 hour day. This average improved to 97% for the second half of the year.

Event Processor

The Event Processing system does not operate in a continuous mode, so a true measure of EP performance must be computed in terms of time covered by the Daily Summary rather than system operating time. The maximum reporting time available to EP is the DP recording time. A convenient presentation of EP daily reporting time is the

histogram of EP reporting time (percentage) versus day, which is given in Figure 4. From February through March 29, 1971, the EP system threshold for signal acceptance was 16 db. From then until December 31, 1971, the EP threshold was set at 14 db. Further information on system operational parameters may be found in SAAC Report No. 5 (Dean, 1972).

On most days EP need not run 24 hours per day to process all of the signals detected by DP. However, since EP operates with the shared disk detection queue, EP must operate a certain portion of each day to insure that this queue does not overflow.

Losses of reporting time due to queue overflow were caused because some failure on the EP computing system prevented it from operating at the necessary level. Enlargement of this queue should reduce these problems. All other outages were due to no DP recording.

From February 1 through March 31, 1971, the long reporting outages (Figure 4) were due mainly to system errors and familiarization difficulties. After June virtually all EP reporting outages were due to no DP being available.

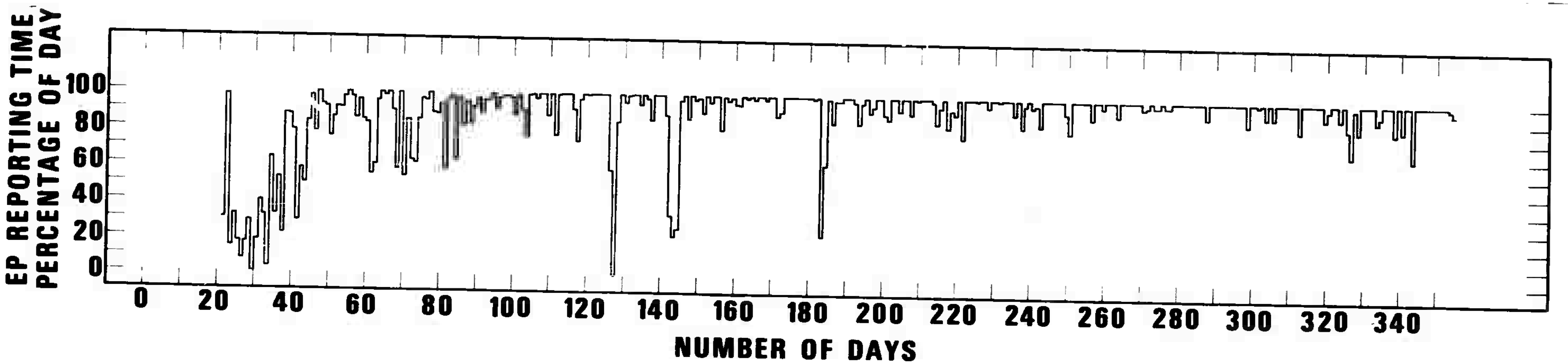


Figure 4. EP daily reporting time (percentage).

The monthly summary of EP reporting outages by probable cause is shown in Table II for the period from March 1 through December 31, 1971. Operational problems, which included familiarization in the early months, caused the most EP outage. From Table II software problems accounted for 30% of all EP outage, operational problems for 43%, and hardware failures for 26%. From March 1 through December 31, 1971 there were only a total of 62 reporting hours lost out of a possible 6953.3 DP recording hours, yielding a 0.8% failure for this period.

Table III is a monthly summary of EP running time in hours. From those values the computed average daily running time of the EP system was 16.9 hours per day (70%). The rest of each day was used for supportive functions, repairs and maintenance. If DP were to operate 100% of the time available, the EP average daily running should increase 0.5 hours or a total of 17.4 hours (77%), assuming the same thresholds were used.

Table IV summarizes hardware/software repairs made during the year. Note that hardware problems on the EP system were more prevalent in the first part of the year. This was also true of the DP system (Table I).

	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Software	3.5	11								4.5	19
Operational	6.5	10.5	10								27
Hardware	11	4	1								1[illegible]
Total	21.0	25.5	11							4.5	62.0
EP Reporting Time	646.0	653.1	675.3	646.4	698.3	720.3	700.0	735.4	705.5	710.0	6941.3
DP Recording Time	667.0	678.6	686.3	646.4	698.3	720.3	700.0	735.4	705.5	715.5	6953.3
Percent of Recorded Time Reported	97%	96%	98%	100%	100%	100%	100%	100%	100%	99.5%	99%

Table II. Summary of Hours of EP Reporting Outages

	Apr	May	Jun	Jul	Aug.	Sept	Oct	Nov	Dec	Total
EP Uptime	457.7	588.9	559.7	550.0	537.0	499.0	500.2	453.1	499.6	4645.2
Possible hours	720	744	720	744	744	720	744	720	744	6600.0
% EP Uptime	64%	79%	78%	74%	72%	69%	67%	63%	67%	70%

Table III. Summary of Hours of EP Operating Time

Month	No. of Summary Events	EP Run Time
Apr	442	457.7
May	911	588.9
June	633	559.7
July	917	550.0
Aug	786	537.0
Sept	720	499.0
Oct	556	500.2
Nov	531	453.1
Dec	921	499.6
Total	6417	4,645.2

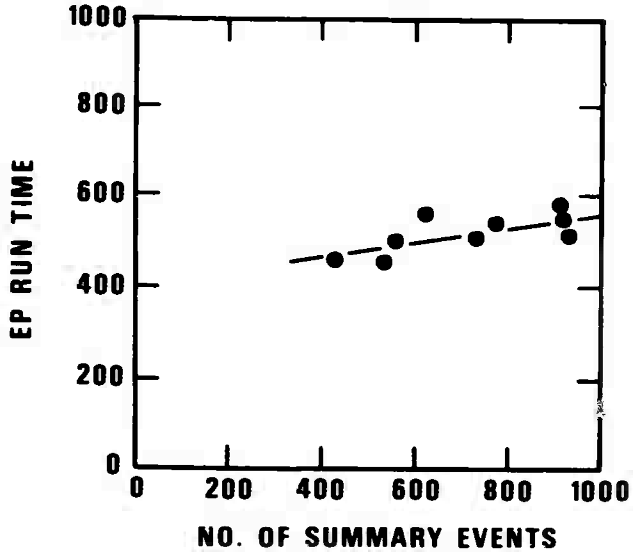


Figure 5. Relation of event activity and EP operating time.

There is usually a delay between the occurrence of software problems and their corrections. For example, the software corrections in February and March shown on Table IV reflect system errors found in January and February.

Figure 5 shows the relationship between monthly events and monthly EP running time for the 9 months from April through December, 1971. As expected, when the seismic activity was high the EP running time was high. The computed correlation coefficient for the plotted monthly EP operating time versus activity to a line is .68, which is significant at the 95% confidence level for this size sample (Appendix A).

Examination of EP running time on the days of the highest activity shows an average of 22.6 hours (94%) being used. Table V is a list of those days showing the activity level in number of events on the event bulletin and the EP system operating hours required. The EP system processed at virtually full computer capacity on those days.

Experimental Operations Console

An analyst spends a portion of each day, usually in three sessions, reviewing event processing results at the Experimental Operations Console (EOC). Figure 6 shows the hours spent by the analysts each day on the

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Central Processing Unit	1		4	1	2					1		2
Tape Unit	2	1			2				1			
Display Controller			1	2								
Shared Disk				2	1							
Operator Typewriter Console									1			
Disk Controller									1		1	
Operator Typewriter Controller										1		
Printer												1
Software Corrections		1	3	2				3		1		
TOTAL	3	2	8	7	5	0	0	3	3	4	1	3

Table IV. Summary of the Number of EP Hardware/Software Repairs

Date	No. of Events	No. of EP hours*	EOC hours
May 12, 1971	84	19.5	9.5
July 26, 1971	71	23.8	8.0
August 18, 1971	71	23.8	9.7
September 6, 1971	58	20.9	6.2
December 15, 1971	116	22.2	9.5
December 16, 1971	85	24.0	11.4
December 18, 1971	68	22.8	5.0

* The EP running hours were measured for the 24 hour period following the first of the swarm of events. Number of events and EOC hours are measured for the 24 hour period beginning at 00:00 on the day shown

Table V. EP Operating and EOC Operating Hours on Seven Days of High Seismic Activity

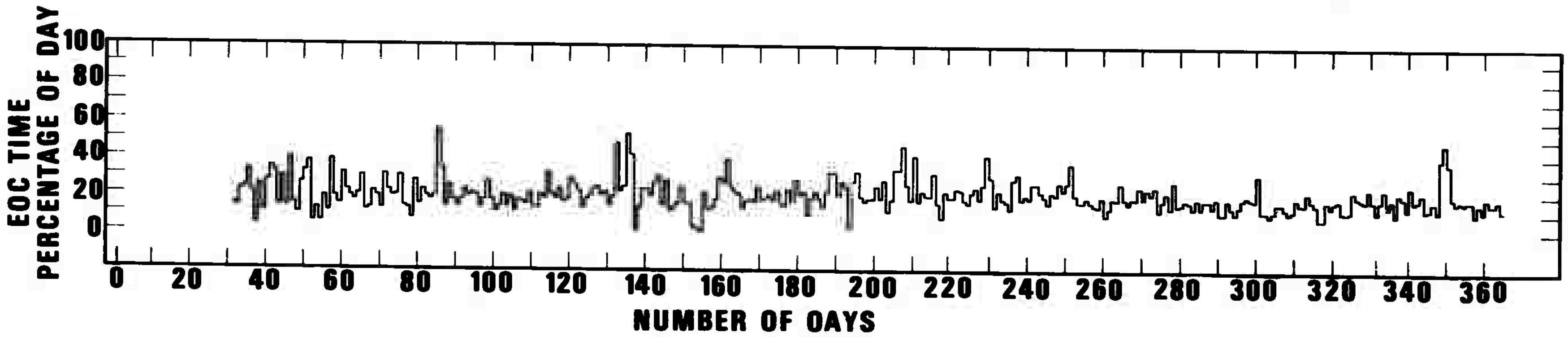


Figure 6. Daily EP-EOC analyst time.

EOC throughout 1971. This represents approximately half of the time actually required by the analyst to edit the event bulletin. The average daily time from February 1 through December 31, 1971, is 4.6 hours (Appendix B). From July 1 through December 31 the average daily time improved to 4.5 hours. For the seven high activity days listed in Table V the daily average was 8.5 hours. The distribution of daily EOC time is given in Figure 7.

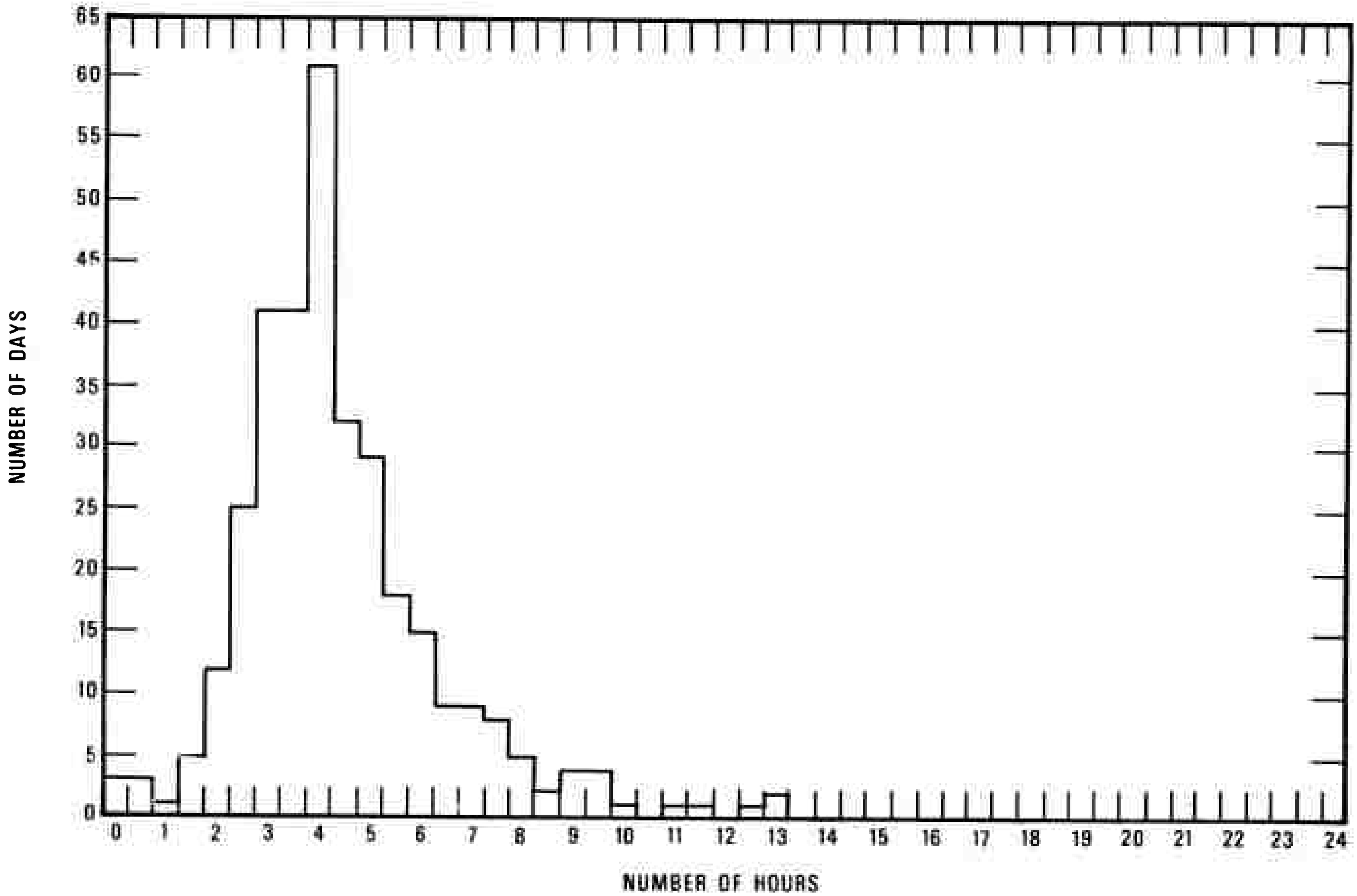


Figure 7. Distribution of EOC analysis time.

ALTERNATE EQUIPMENT UTILIZATION

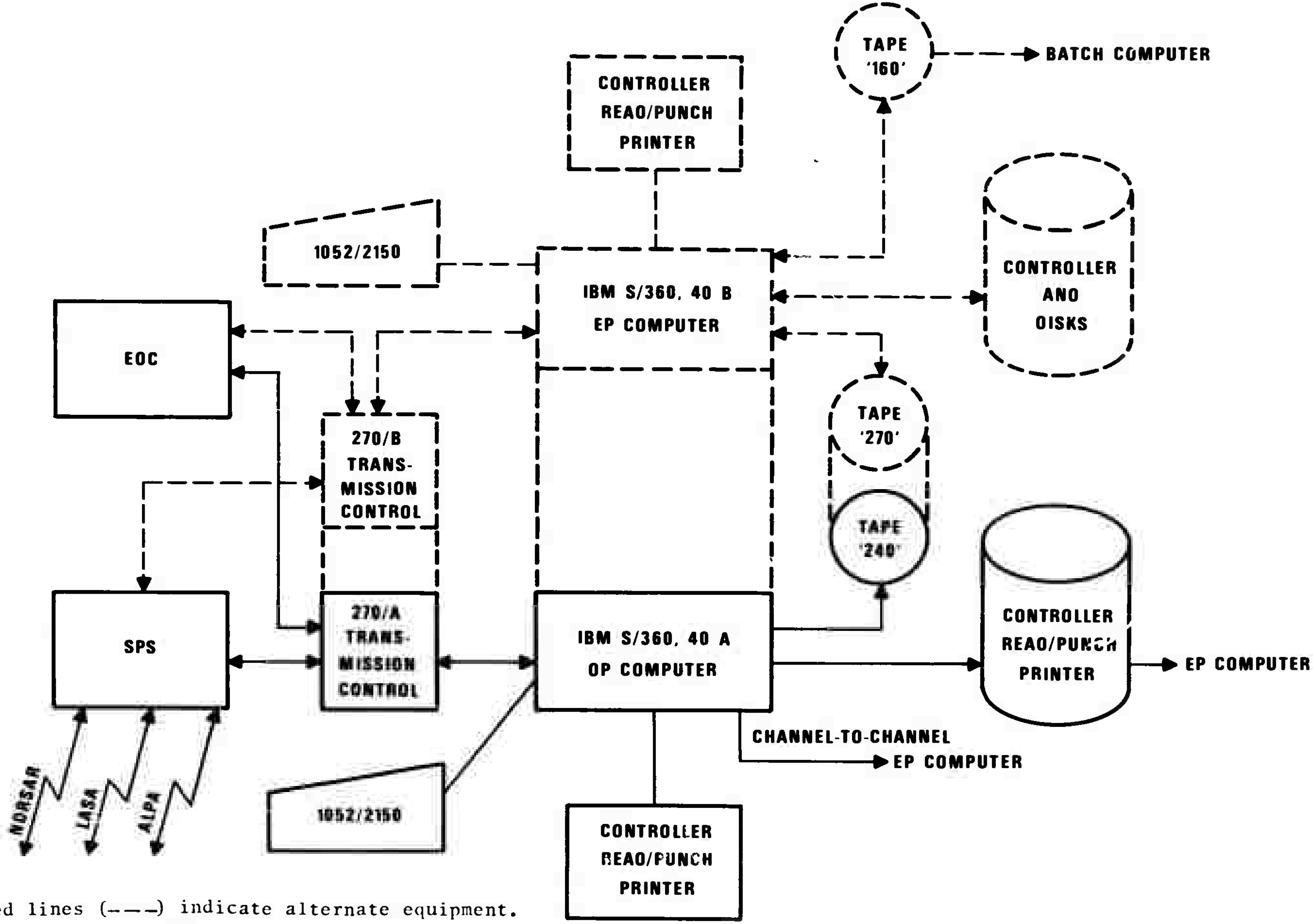
Configuration

The function with the highest priority in the SAAC system is the recording of seismic data. Therefore, if the DP computer system fails, the DP system can operate on the EP computer system while the failure is being repaired. This is accomplished by switching units. Single components of the basic EP computer system can be switched into use as illustrated by the diagram in Figure 8.

The alternate 2701 transmission control unit is directly switchable for use by the DP computer to interface with the SPS and EOC. The 2804 tape controller with tape units addressed as "270" is also directly switchable for use by the DP computer. All other backup peripherals are only usable through the EP computer.

The SAAC system has alternate software backup for use when the SPS is not operational. The 50 kilobit line from LASA is switched through a 2701 transmission control to the S/360/40A computer. The IISPS (Interim Integrated Signal Processing System) DP system is then used for LASA data recording and signal detection.

When the 50 kilobit line is down there is backup recording at LASA.



Dotted lines (---) indicate alternate equipment.
All switching is achieved through a switch unit.

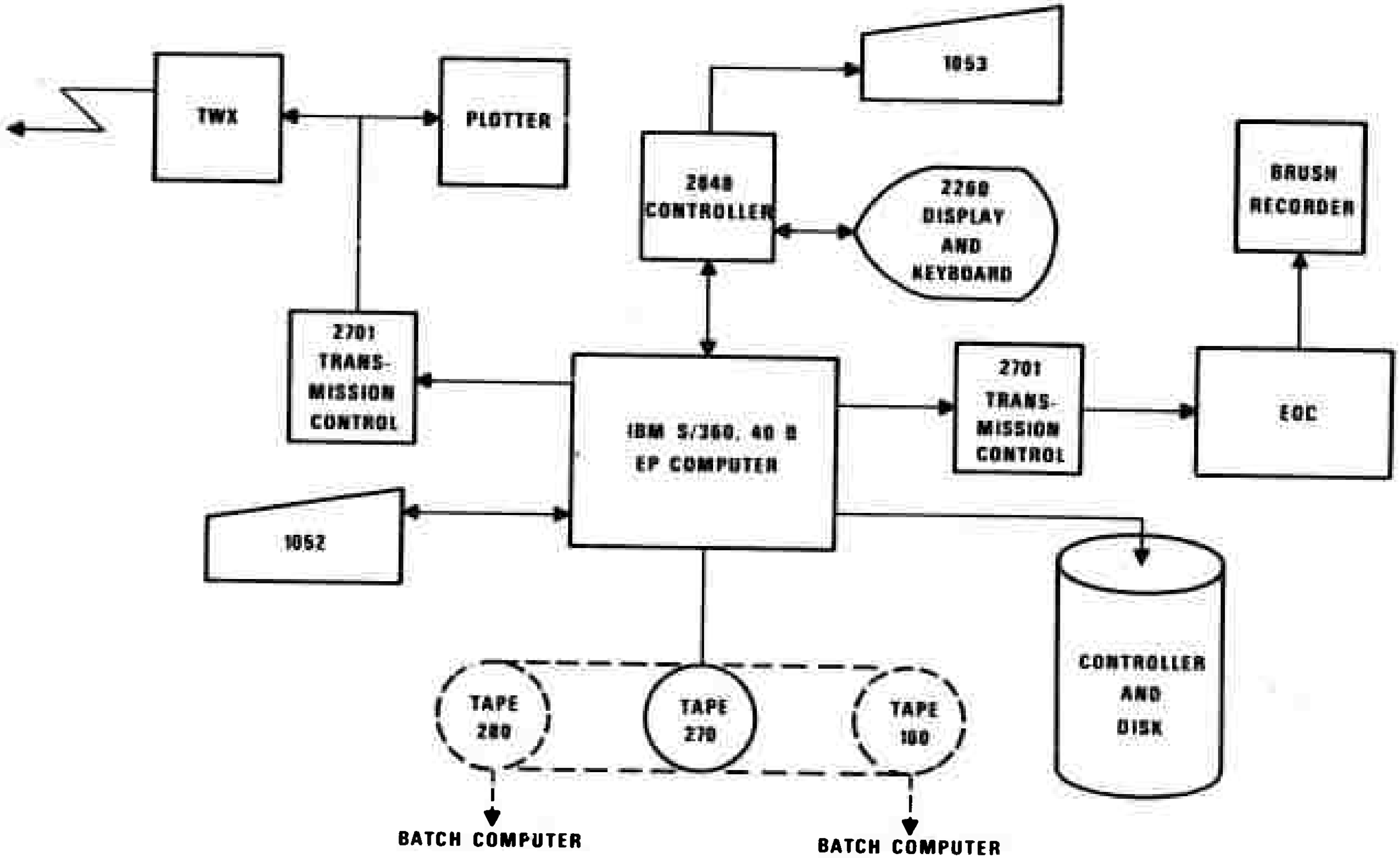
Figure 8. Diagram of DP alternate equipment.

The Event Processing System alternate equipment configuration is shown in Figure 9. A tape controller with associated tape units is the only alternate equipment on the EP System.

Utilization

Table VI is a monthly summary of software and equipment problems and associated utilization of ISRSPS DP alternate equipment. The high incidence of short downtime periods is due to the fact that when a failure occurs a time of 5 to 10 minutes is necessary to reinitiate the DP operation whether or not an alternate piece of equipment is being used. Also whenever a software or parameter change is made it is necessary to reinitiate the DP operation with a resulting short period of downtime. When the DP computer is down, and the EP computer (40B) is to be used as backup, there may be an additional DP recording loss while the EP system finishes processing work in progress.

Table VI shows that only tapes and Central Processing Units were backed up during the period from August 1 through December 31, 1971. In August switchable tape capability kept ISRSPS DP in operation 2.7 hours or 0.4% of DP uptime and in September the alternate Central Processing Unit kept DP in operation 2.5 hours of 0.35% of DP uptime. This backup accounted for only 0.15% of DP's uptime during the five month period.



Dotted lines (— — —) indicate alternate equipment.
All swit ing is achieved through a switch unit.

Figure 9. Diagram of EP alternate equipment.

	AUG		SEPT		OCT		NOV		DEC	
	down	backup	down	backup	down	backup	down	backup	down	backup
Reinitialization (Software/Hardware)	.3	0			.7	0				
Central Processing Unit			2.3	2.5					.5	0
Tape Controller	2.0	0								
Tape drive	3.2	2.7					.8	0		
Faulty Tape	.5	0	.5	0			.2	0		
Operator Typewritter									.2	0
Disk			.3	0						
Air Conditioner (not duplicated)					.8	0				
Fire	2.5	0								
Software and Parameters	.2	0	.7	0	1.0	0	.2	0	.6	0
EOC (not duplicated)	.3	0								
Total	9.0	2.7	7.8	2.5	2.5	0.0	1.2	0.0	1.3	0.0
Net Downtime	6.3		5.3		2.5		1.2		1.3	
Percent of DP Downtime covered by backup	30.6%		33%		0%		0%		0%	
Percent of Uptime Due to backup	0.38%		0.35%		0%		0%		0%	
Average for 5 months	.146% of uptime due to backup									

Table VI. Comparison of Component Downtime and Backup Time (Hours)

The alternate equipment (EP computer system) was important for testing changes and corrections to the DP system and also for conducting experimental comparison projects using the off-line version of DP on the EP computer.

SYSTEM FLEXIBILITY

Special Processing System

The Special Processing System (SPS) developed and built by IBM is a stored program digital computer which acts as a communication controller on the DP system. The SPS uses standard components of the IBM 360 computer line but is unique in the way these components are integrated. Its functions are controlled by microcoded routines stored in Transformer Read Only Storage. The microcode instruction format is complicated and it can only specify simple operations. Each of these operations executes in one 0.5 microsecond cycle.

The internal components of the SPS are: Transmission Adapter Unit, which contains the interface to control the data communication lines; Transformer Read Only Storage (TROS), which contains the micro-instructions; TROS Sequence; Main Store; Data Flow for data transfer under microprogram control; Storage Access Channel for a direct access to Main Store; and Multiplex Channel (Figure 10).

As a communications interface the SPS can control 32 full duplex synchronous lines of various bit rate, or half may be asynchronous at 120 bits per second, and it can control up to eight binary synchronous Communication Adapters which can operate at data rates up to 50,000 bits per second, full duplex. The SPS can communicate with two S/360 computers effectively through a 2701 parallel Data

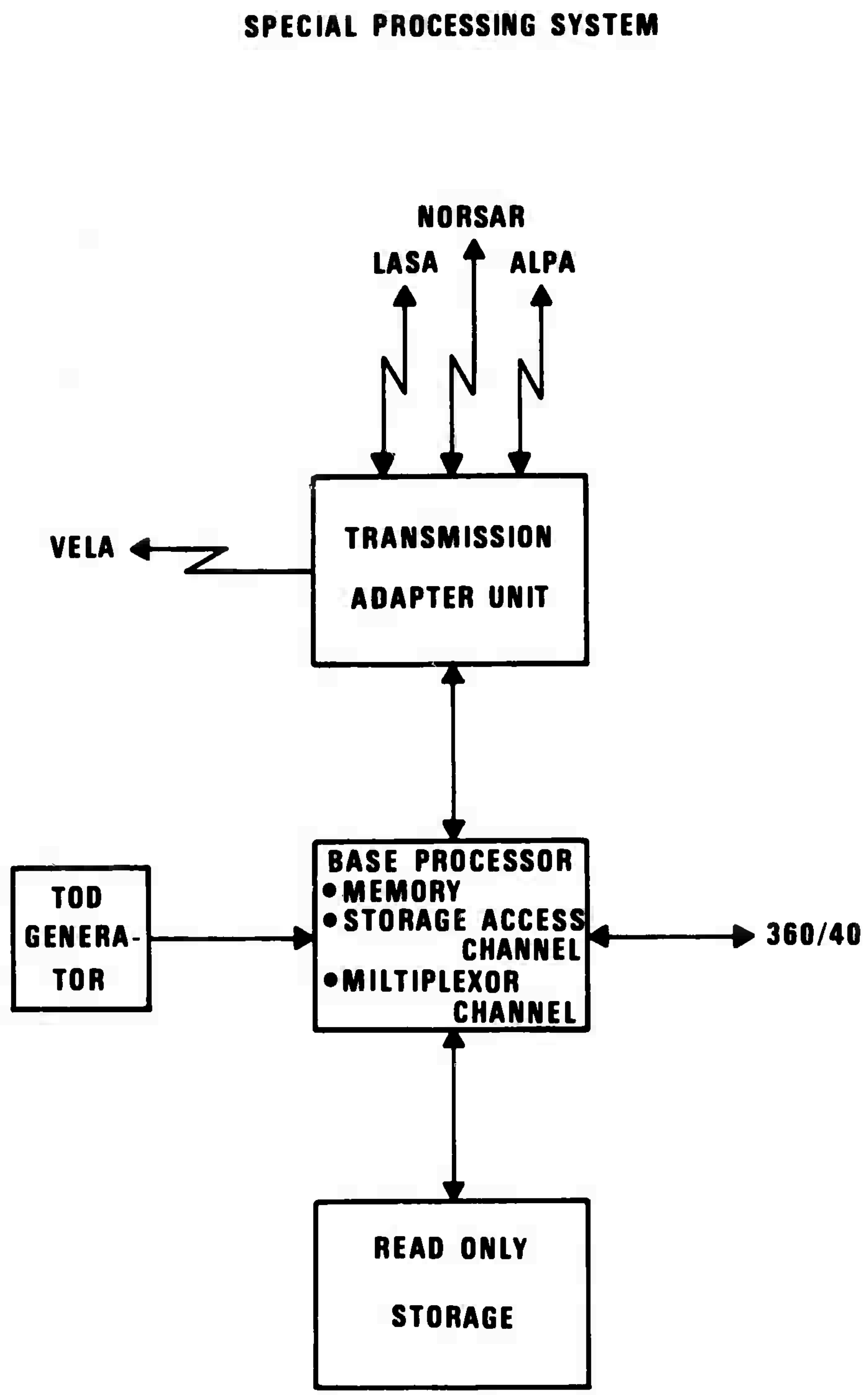


Figure 10. Diagram of special processing system.

Adapter because of the SPS's comprehensive interrupt logic.

The speed of the SPS is more than adequate for its current functions of data aquisition, formatting, filtering and subarray beamforming since approximately half of its computing capacity is utilized. However, the storage in the TROS and Main Store is almost consumed.

The SPS programming is parameterized to some degree using initial core load from the IBM S/360 Model 40 computer. But the TROS must be changed to implement logic changes and making these changes is complicated. The microprogram must be coded and assembled in the microassembly language and tested on an SPS simulator until the change is working. Next TROS tapes must be punched from the microprogram assembler output and installed in the SPS TROS and tested. Minor corrections may be punched by hand on the TROS tape; otherwise one must remake the TROS tape as before.

The modification process requires use of a microprogram assembler, SPS simulator, special equipment for making the TROS tape as well as a trained technician for its installation. Testing on the SPS requires use of the IBM S/360 for initial core load and memory dumps. Since neither the microprogram assembler nor the SPS simulator are user-available IBM programs, they would

have to be implemented by Teledyne Geotech or obtained from IBM through contract agreement before any significant changes could be made.

Even with the microprogram assembler and SPS simulator, the cost of an SPS microprogram change would be at least twice that for a comparable S/360 change excluding purchasing, punching and installation of TROS tapes. Similarly, hardware changes to the SPS would be more costly than comparable items on the 360 because they would have to be custom built and installed.

Should more memory be added, the current addressing scheme would be inadequate. All bits of the address field of the instructions are currently used for the 65,536 word memory size. Therefore a different address scheme would have to be used if more memory were added. A similar condition exists concerning the TROS size.

The SPS is quite inflexible, for two reasons: (1) the time and cost of hardware and firmware changes, both permanent and experimental, and (2) its inability to interface to peripherals without a 360 CPU. However, the SPS is adequate for its current functions and has excellent hardware and microprogramming reliability (Pinkerton, 1971).

Detection Processor

The Detection Processor Programming system is organized into units (tasks) by logical function. These units operate asynchronously. When a particular function is needed it is activated by another function or an input/output or timer interrupt. Table VII shows a list of all DP functions and the percentage of the time available used by the Central Processing Unit (CPU) in performing the various functions over a 33 hour period of time. The data used in the chart is from June 1971 and is typical of DP operation. The amount of CPU utilization by the data acquisition, tape recording, and detection processing tasks is essentially constant. The time expended waiting on transfers of data between external storage devices and memory and waiting on the next string of data from the SPS is unused CPU capacity. This wait time was 43% of the total.

Table VIII shows the computer memory utilization by DP tasks. The entire DP system is resident in memory throughout DP operation and requires 246,000 bytes. The remainder of memory storage (16,000 bytes) is required by the Disk Operation System.

The system is modular; however, the lack of available memory would prevent programming additions of significant size without incorporation of dynamic program loading,

		Jun 22	June 23	Jun 24	Jun 24	Jun 25
	from	12/40/20.5	19/56/38.0	13/13/36.5	18/46/46.0	21/10/37.0
	to	21/01/37.0	21/18/06.0	18/46/46.0	21/10/37.0	12/34/25.0
Data Acquisition		10.2%	9.9%	10.1%	10.4%	10.5%
Tape Recording		2.5%	2.6%	2.5%	2.6%	2.5%
High Priority Messages		0.0%	0.0%	0.0%	0.0%	0.0%
EOC Test Times		2.6%	2.6%	2.6%	5.2%	6.6%
Detection Process		41.1%	40.9%	40.9%	40.9%	40.9%
Lowpriority Messages		0.1%	0.1%	0.1%	0.1%	0.1%
Disk Recording		0.0%	0.0%	0.0%	0.0%	0.0%
Wait		43.3%	43.7%	43.6%	40.6%	39.1%
TOTAL		99.8%	99.8%	99.8%	99.[illegible]%	99.7%
	(hours)	8/21/16.5	1/21/28.0	5/33/09.5	2/23/51.0	15/23/48.0

Table VII. DP CPU Utilization by Task (percentage)

DP Function	Bytes of Memory
DP Monitor	14,000
Data Acquisition	26,000
Tape Recording	10,000
Message Function	25,000
EOC Function	11,000
Detection Process	6,000
Disk Recording	6,000
Work Storage	40,000
Free (small blocks)	1,000
DP Constants and Data Areas	107,000
TOTAL	246,000

Table VIII. DP Memory Utilization by Function

or elimination of a nonessential task (such as the EOC task). There are also several memory data addressing restrictions imposed by certain of the special filtering and beamforming instructions, which must be observed in any program modifications to the DP system.

Event Processor

The Event Processor programming system is organized in a heirarchy of functions providing the capability of dynamic loading of programs from disk. The main memory of the computer is used as four time-sharing units, allowing EP to process up to three events concurrently. There is an EP monitor program and data area composing one unit and three processing units or regions used for loading and executing the various analytical and data management programs (Figure 11).

The analytical operations shown in Table IX are performed for individual events. The average analysis time per event is 382 seconds. Correlation analysis requires almost twice as much CPU capacity as any other operation.

Besides the analytical operations listed in Table IX, several EP system functions operate on groups of events and are largely I/O operations requiring relatively little CPU capacity. These EP data management functions are responsible for production of a detection report,

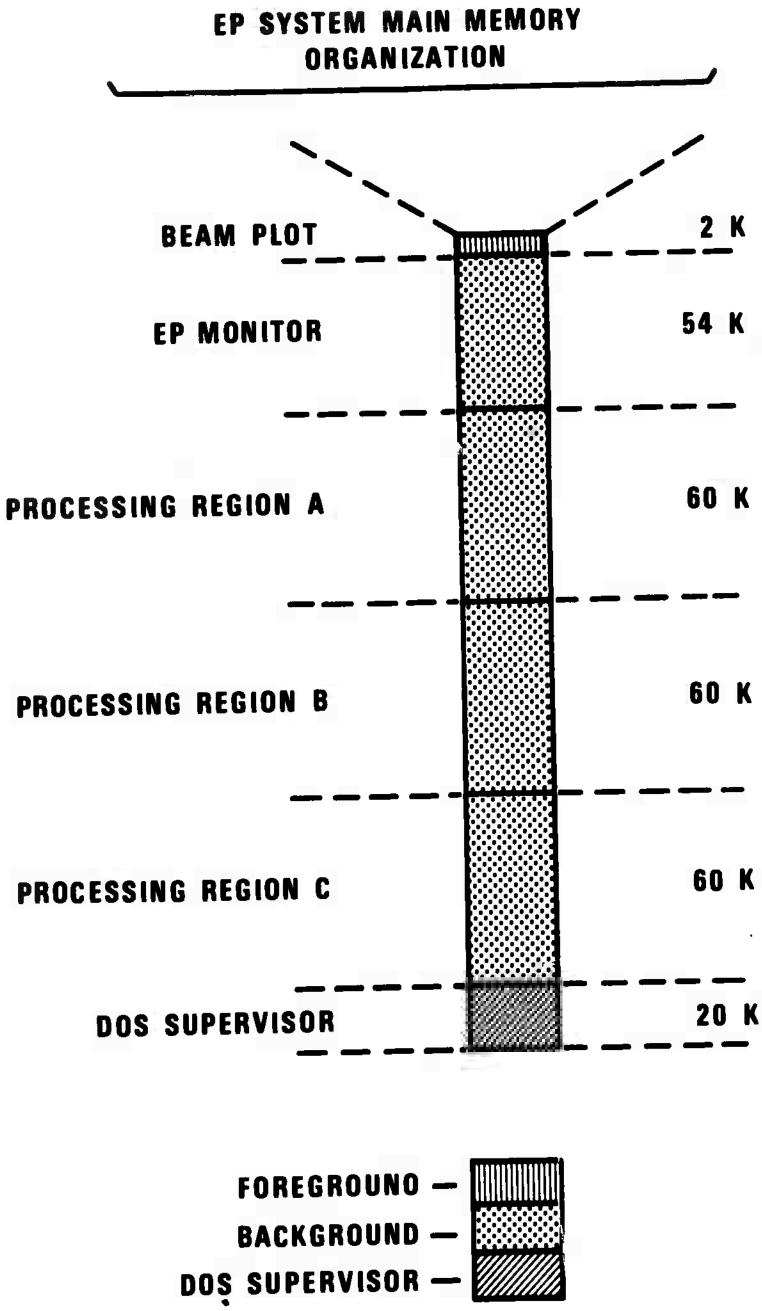


Figure 11. Diagram of EP memory utilization.

Data from EP Analysis of March 16, 1971

Package	Function	Time (seconds)	%
SP01	Beamforming	4134.8	22.6
SP02	Correlation	8547.3	46.7
SP03	Beam Packing	1280.0	7.0
SP04	Event Parameter Extraction	2943.9	16.1
SP05	Calibration	1382.3	7.6
SP06	Event Characterization	2.0	.0
	TOTAL	5.1 hours	100.0

Table IX. EP CPU Utilization by Analysis Task

bulletin report, and summary report (on each event in the bulletin). The beam plot tape and event tape generator and EOC analysis also operate in this mode.

Of the 262,000 bytes of memory on the EP computer, there are approximately 20,500 bytes for the Disk Operating System supervisor, 55,000 bytes for the EP monitor and common data area, 61,500 bytes for each of three processing regions or (184,500 bytes total) and 2,000 bytes for the off-line plot program (Figure 11).

The smallest loadable program unit in the EP system is called a "package"; usually a package performs a single function. One or more packages compose a larger function called a "job step." One job step occupies a region of memory. The packages are loaded and executed one at a time until the job step has completed operation. Table X shows the memory required by each package. Note that only one package is in a region of memory at a time. Therefore the largest package must not exceed the region size which is 61,500 bytes.

The Event Processor appears to be organized for maximum usage of memory and CPU capacity. Its basic design allows it to be more easily modified than does the DP system.

	EP Package	Bytes of Memory
SP01	Beamforming	53,000
SP02	Correlation	61,400
SP02	Beam Packing	50,000
SP02	Event Parameter Extraction	47,000
SP02	Calibration	29,000
SP02	Event Characterization	21,000
SP03	Parameter Report Generation	44,000
SP03	Summary Report Generation	53,000
SP03	Event Tape Generation	51,000
SP03	Detection/Bulletin Generation	44,000
SP03	Recording Plot Tape	44,000
SP04	EOC Interface	61,000
SP04	Event Tape Data Retrieval	18,000
MON.	EP Monitor, Common Data Area, and Rerun Processor	55,000
	Large Event Processor	6,000

Table X. EP Memory Utilization by Function

CONCLUSIONS

The conclusions concerning the equipment and software of the SAAC (LASA) System as it operated from January 15 through December 31, 1971, are:

1. The Detection Processor computing system recorded LASA data 91.3% of the time from January 15 through December 31, 1971. From July 1 through December 31 the DP system recorded LASA data 97% of the time.
2. The 50 kilobit line between LASA and SAAC was the least reliable part of the system and accounted for 38% of the total LASA data recording time lost. These failures were generally associated with bad weather conditions along the route of the line.
3. The Special Processing System had substantial down time in the early months only. It appears that these may have been caused at least in part by the relocation of the SAAC in early January 1971.
4. The Event Processor system reporting coverage was 99% of the DP recording time. Most of the EP reporting outages occurred in the early months of the contract period and were due mainly to software errors and familiarization difficulties.
5. The EP required an average operating time of 17 hours per day to process selected events from all data and signals recorded per day by the DP.

6. The daily time required by a seismic analyst operating the EOC was less than five hours. The maximum time required on any day was 13 hours.

7. The alternate equipment within the SAAC system was of virtually no use in increasing the recording and reporting time. This was because the most troublesome pieces of equipment were the 50 kilobit LASA line and the SPS, which are not duplicated, whereas the IBM S/360 Model 40 computing systems had a high degree of reliability.
8. The alternate equipment within the SAAC system provides flexibility for testing and experimenting with the DP system.
9. The Special Processing System uses about half its computing power but nearly all of its storage capacity. Changing the SPS logic would be difficult, time-consuming, and costly, because all the logic is microprogrammed (tools for which are not readily available); there are no attached I/O devices for convenient testing; and the current micro-instruction format prohibits additions to the size of the TROS storage and memory.
10. The Detection Processor uses approximately 50% of its computing capacity. The entire programming system is resident in memory while the DP system is operating. The system is modular, but the addition

of tasks might require dynamic program module loading because no appreciable memory is presently available. Additional memory could be made available if some non-essential task, such as the EOC task, were eliminated.

11. The Event Processor is organized for maximum usage of memory and CPU capacity. The EP system is modular and therefore is relatively easy to change and supplement.

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Special Processing System Study, (1971), Pinkerton Computer Consultants, Inc., Arlington, Virginia.

APPENDIX A

Month	Average Daily Hours	Total Monthly Hours
February	4.9	136
March	5.0	156
April	4.2	126.9
May	5.3	165.2
June	4.3	129.6
July	5.4	168.5
August	5.0	154.7
September	4.5	135.4
October	3.8	117.0
November	3.6	106.9
December	4.4	135.5
Total	50.4	1531.7
Average	4.6	139.24

Average Daily EP EOC Analysis by Month

APPENDIX A

APPENDIX B

APPENDIX B

Correlation Coefficient:
Monthly Activity Level by Monthly EP Operating Time

	x		y		x^2		y^2		xy
	442		457.7		195.364		209,489.29		202,303.4
	911		588.9		829.921		246,803.21		536,487.9
	633		559.7		400.689		313,264.09		354,290.1
	917		550.0		840.889		302,500.00		504,350.0
	786		537.0		617.796		288,369.00		422,082.0
	720		449.0		518.400		249,001.00		359,280.0
	556		500.2		309.136		250,200.04		278,111.2
	531		453.1		281.961		205,299.61		240,596.1
	921		499.6		848.241		249,600.16		460,131.6
(Σx)	6,417	(Σy)	4,645.2	(Σx^2)	4,842.397	(Σy^2)	2,414,526.40	(Σxy^3)	3,357,632.3

Computation of r:

$$r = \frac{n(\Sigma xy) - (\Sigma x)\ (\Sigma y)}{\sqrt{[n\ (\Sigma x^2) - (\Sigma x)^2]\ [n\ (\Sigma y^2) - (\Sigma y)^2]}}$$

$$r = \frac{9\ (3,357,632) - (6,417)\ (4,645)}{\sqrt{[9(4,842,397) - 6,417^2]\ [9(2,414,526) - 4,645^2]}}$$

$$r = .68$$

Significance of r:

$$t = \frac{r}{\sqrt{1-r^2}} (\sqrt{n-2}) \text{ for 8 degrees of freedom}$$

$$t = \frac{.68}{\sqrt{1 - (.68)^2}} (\sqrt{9 - 2})$$

$t = 2.4645$ (α for t of 2.46 $<$ .025)